# Space Weather Technical Forecast

Issued on Saturday, 08 June 2024 at 12:01 Local

**This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales**

## Space Weather Forecast Headline: Chance of S3, gradually relaxing. G2 now Likely in UTC day of Monday 10 June. R1/R2 Expected, risk easing into new UTC week.

## Analysis of Space Weather Activity over past 24 hours

**Solar Activity:** Activity has been Moderate at GOES16/18 during the last 24 hours, with occasional M-class flares, peaking with an M9.7 from AR3697 at 08/0149UTC. This event generated a Coronal Mass Ejection (CME) as well as a 10cm radio burst, Type IV and II radio signatures, with the last of these giving an estimated CME speed of 894km/s. The ejecta show a (possibly double-lobed) asymmetric halo on coronagraphs. Three space weather advisors' analyses have been used and MOSWOC Enlil modelling suggests a 1AU crossing time of 10/0600UTC, i.e. the start of the UTC day Monday 10 June. No other new CMEs were noted in the period.

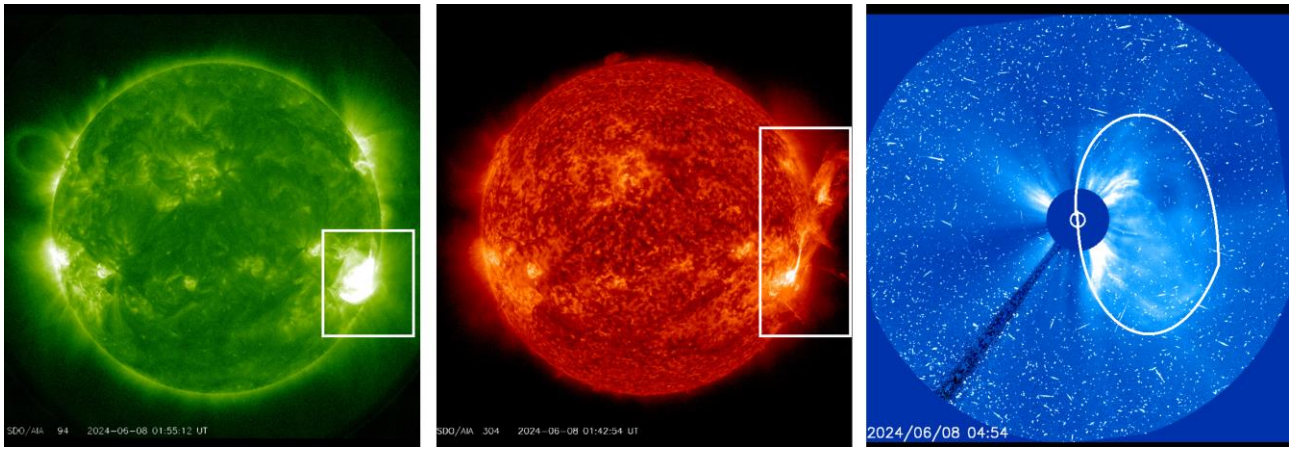


**Figure 0: Various views of the 08/0149UTC M9.7 flare from AR3697 – respectively AIA94, 304 and Lasco C3. Note also the particle 'snow' from the ensuing S3 major solar radiation storm on the C3 CCD.**

There are currently up to ten sunspot regions on the disc. The apportionment for the far southeastern regions not yet clear, with a possible unnumbered region now showing to the east of AR3709, else the latter now covers a very significant span and may move from a Dki/BG to an Fki/BG. The most active region on the disc is AR3697 in the southwest, with this group showing gradual reconfiguration of its constituent parts, all while retaining a Mt Wilson delta in its main penumbra. Less clearly, the group now may also showing rapid development of some small leading spots - the narrow viewing angle is making the continuity of the plage difficult to ascertain and these may yet form a second sunspot region. Otherwise, main changes observed in recent hours have been a reduction in number and area of three further groups' intermediate spots: AR3698, AR3703 and AR3707.

**Solar Wind / Geomagnetic Activity:** Solar winds, as observed by ACE at L1, showed CME



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influence for much of the 24-hour period (starting 07/1050UTC), however from 08/0500UTC a step-wise decrease in density and speed appeared erroneous. Solar wind speeds were thus most likely Slightly Elevated in the upper 400s of km/s throughout, with the density Slightly Elevated at peak in the teens of ppcc before a slight waning. The IMF trace appeared more realistic throughout, with an erratic magnitude that peaked at 14nT, with the north-south component varying between -13nT and +10. The phi angle was changeable throughout, but more decidedly settled on positive (away from the Sun) after 08/0430UTC.

The net result of the above solar wind measures was for a reduction from provisional G2 Moderate geomagnetic storm conditions entering the 24 hours, falling from Kp '6+' to become mainly Unsettled.

**Energetic Particles / Solar Radiation:** High energy (greater than 10 MeV) proton flux observed by GOES18 showed a rapid rise in the wake of the M9.7 flare, rising to an eventual peak of 1030pfu at 08/0800UTC before waning slightly. The spectral response was hard, with 100MeV protons also showing a rise to a peak of around 8pfu before these too began to wane.

High energy electron flux (greater than 2MeV) observed by GOES16 was at Normal Background levels with the associated 24-hour fluence well below Active. Observed fluence at 08/0001UTC was 1.45e6 integrated pfu.

## Four-Day Space Weather Forecast Summary

**Solar Activity:** Further M-class flares are now Expected, with an ongoing Slight Chance of an X-class flare - these most probably from AR3697 or AR3709. The probabilities of both fall slightly by the very end of the four days as a result of the passing from the disc of AR3697.

**Solar Wind / Geomagnetic Activity:** The CME associated with the M9.7 flare shows an asymmetric halo in its shock at least, and there is now considered a risk of G2 Moderate geomagnetic storm conditions through Monday 10 June. This is the only CME in the forecast.

Otherwise, current Slightly Elevated solar winds should slowly ease on day 1 (Saturday 08 June). CH42/+ in the northwest disc could bring renewed Slightly Elevated or possibly Elevated wind speeds for a time later in the current UTC day (08 June), or perhaps more likely into day 2 (09 June).

Initial mainly Unsettled conditions may rise to Active in the next 24 hours - should any coronal hole fast wind onset occur. Moderate geomagnetic storm G2 is now considered Likely on Monday 10 June before waning to Quiet by the end of the four-day period.

**Energetic Particles / Solar Radiation:** High energy proton flux should now show a very gradual waning tendency from its S3 peak, although proximity to this level means that any further suitable events from AR3697 may see the trace rise once again. S2 is therefore Expected at first, with a Chance of S3, falling to an Expected S1 into Sunday 09 June. The risk should fall further to mirror the raw value for the sunspot regions on the disc by Tuesday 11 June.

High energy electron flux is forecast to persist at Normal Background levels, and the associated 24-hour fluence forecast should remain below the Active threshold. There is a Slight Chance of recovery on the final day of the period, Tuesday 11 June in the wake of any CH42 and CME influence.

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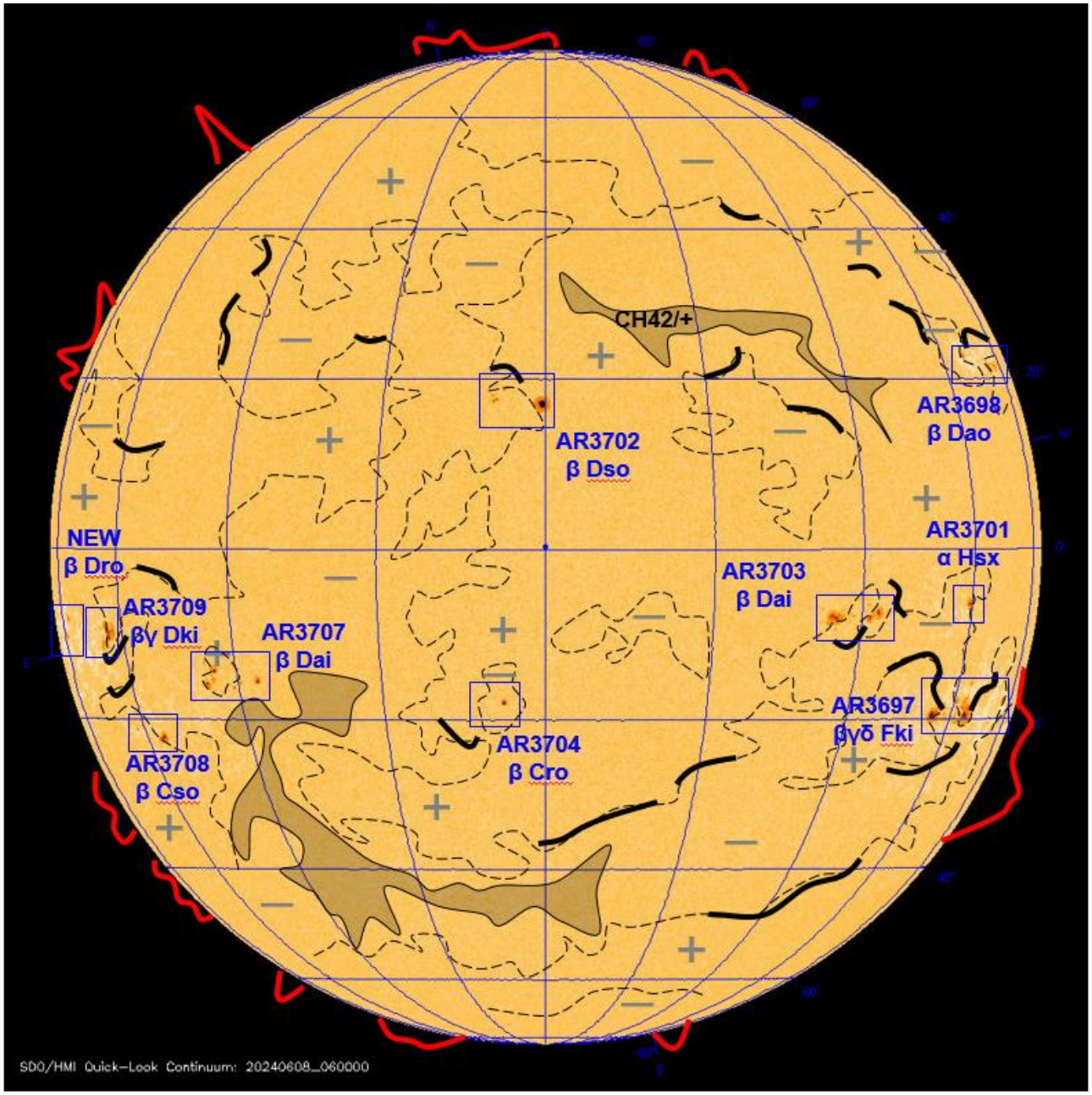
**Figure 1. Solar Analysis Valid 08/0600UTC.**




**Key:** Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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## Geomagnetic Storms:

The M9.7 flare from AR3697 at 08/0149UTC in the southwestern disc generated a Coronal Mass Ejection (CME). A substantial coronal dimming and EUV wave were also seen, with the latter crossing the solar meridian in the minutes following the flare. Also observed were a 10cm radio burst, Type IV and Type II radio signatures, with the last of these giving an estimated CME speed of 894km/s. The ejecta show a (possibly double-lobed) asymmetric halo on coronagraphs. Three space weather advisors' analyses have been used and MOSWOC Enlil modelling suggests a 1AU crossing time of the very start of the UTC day Monday 10 June. Most of the ejecta appears directed south and west of the Sun-Earth line, but there may be up to two shocks that appear to impinge on the Sun-Earth line, and a glancing blow of some description is therefore expected. No other new CMEs were noted in the period.

An un-forecast CME arrived immediately prior to the start of the current reporting period around 07/1050UTC, increasing geomagnetic activity from Quiet to Unsettled to G2/Moderate storm levels for a time 07/1200-1500UTC, before waning to Unsettled levels thereafter. Solar winds, which had been at Background levels, increased to become Slightly Elevated following this CME arrival. These winds should now slowly ease following the CME passage on day 1 (08 June). However, there is another potential enhancement from the elongated and rather narrow CH42/+ in the northwest disc could bring renewed Slightly Elevated or possibly Elevated wind speeds for a time later on day 1 (08 June), or perhaps more likely into day 2 (09 June). Comparison with imagery from last rotation shows a similarly-shaped coronal hole in this position, although this was more well-defined on last pass. However, solar wind from the previous rotation was dominated by the arrival of fast CMEs, so persistence will not provide a guide.

MOSWOC ENLIL model output supports some weak connection from CH42/+ with similar timings - this also lends some confidence to its thoughts on the inbound CME. All considered, Unsettled geomagnetic activity is expected on day 1 (08 June), but with the potential for some short-lived Active conditions from any coronal hole fast wind onset either late on day 1, or during day 2 (09 June). Moderate geomagnetic storm G2 is now rated as Likely on Monday 10 June before waning to Quiet by the end of the four-day period.

| Geo-Magnetic Storm Probability (Exceedance) | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| **Minor or Moderate** | **G1 to G2** | Yes | 5 | 10 | 70 | 1 |
| **Strong** | **G3** | No | 1 | 1 | 10 | 1 |
| **Severe** | **G4** | No | 1 | 1 | 1 | 1 |
| **Extreme** | **G5** | No | 1 | 1 | 1 | 1 |

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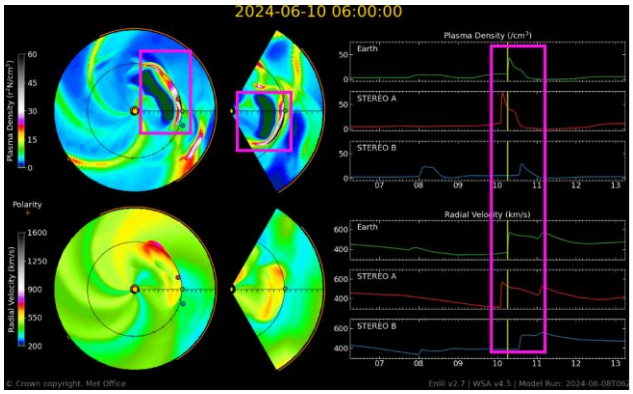
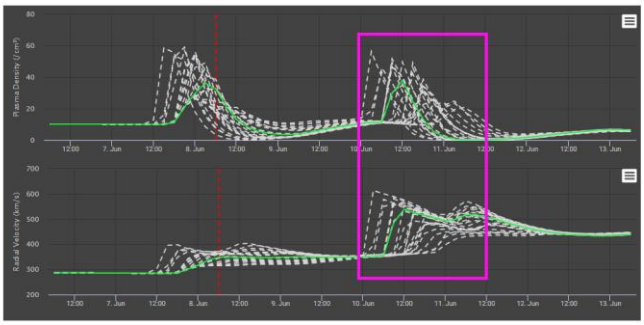
## Geomagnetic Activity - Earthbound Coronal Mass Ejections

| Date/time 21.5R (UTC) | Halo: Full or Partial | Source | Source Location | Estimated Speed | Estimated Arrival Time | Comments |
|---|---|---|---|---|---|---|
| 08/0439 | Partial | AR3697 | SW | 1154km/s | 10/0600UTC | Mainly shock, but large event. Arrival error bars probably contained wholly within UTC morning of 10 June. |

**Figure 2: Latest MOSWOC Enlil run and ensemble (badge time 08/0600UTC), showing boxed in magenta the 08/0149UTC M9.7 CME as crossing 1AU around 10/0600UTC. Enlil's treatment of solar wind conditiosn is felt to be reasonable, lending confidence to the arrival time – most likely within the UTC morning of Monday 10 June.**



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## Radio Blackouts - X-Ray Flares:

Solar activity has been Moderate during the last 24 hours with occasional M-class flares, peaking with an M9.7 from AR3697 at 08/0149UTC. The frequency of events at or above M has led to a slight rise in the daily risk of further such activity while AR3697 remains on the disc, with this the case until the final day of the period. Also of note is the arriving AR3709 in the southeast, with this sunspot region having also contributed to recent M-class activity.

Further M-class flares are now Expected, along with a Slight Chance of an X-class flare, these most probably from AR3697 or AR3709. AR3697 should depart the Earth-facing disc by Tuesday 11 June, leading to an overall slight drop in daily risks, with far-side soundings not suggesting any further substantial arrivals in the period.

| X Ray Flares<br>Probability | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC)<br>(%) | Day 2 (00-24 UTC)<br>(%) | Day 3 (00-24 UTC)<br>(%) | Day 4 (00-24 UTC)<br>(%) |
|---|---|---|---|---|---|---|
| **Active** | **R1-R2 M Class** | Yes | 80 | 80 | 80 | 60 |
| **Very Active** | **R3 to R5 X Class** | No | 15 | 15 | 15 | 10 |

## Solar Radiation Storms - (High Energy Protons):

AR3697 is now in a prime position to deliver S-scale enhancements should it flare suitably. Given the enhanced levels of greater than 10MeV protons in the interplanetary medium, this means further exceedence of S3 is now rated at a Chance, with this risk falling the more time that elapses between proton-rich flares. S2 is therefore Expected at first, with a Chance of S3, falling to an Expected S1 into Sunday 09 June. The risk should fall further to mirror the raw value for the sunspot regions on the disc by Tuesday 11 June.

Greater than 100MeV protons should show a similar relaxing trend from its 8pfu high, probably fully relaxing to resting background in around 48 hours' time - again, barring new events.

| Radiation Storms<br>Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $s^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC)<br>(%) | Day 2 (00-24 UTC)<br>(%) | Day 3 (00-24 UTC)<br>(%) | Day 4 (00-24 UTC)<br>(%) |
|---|---|---|---|---|---|---|
| **Active** | **≥ S1** | Yes | 100 | 80 | 30 | 20 |
| **Very Active** | **≥ S3 *** | Yes | 30 | 20 | 5 | 5 |
| * S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$) | | | | | | |

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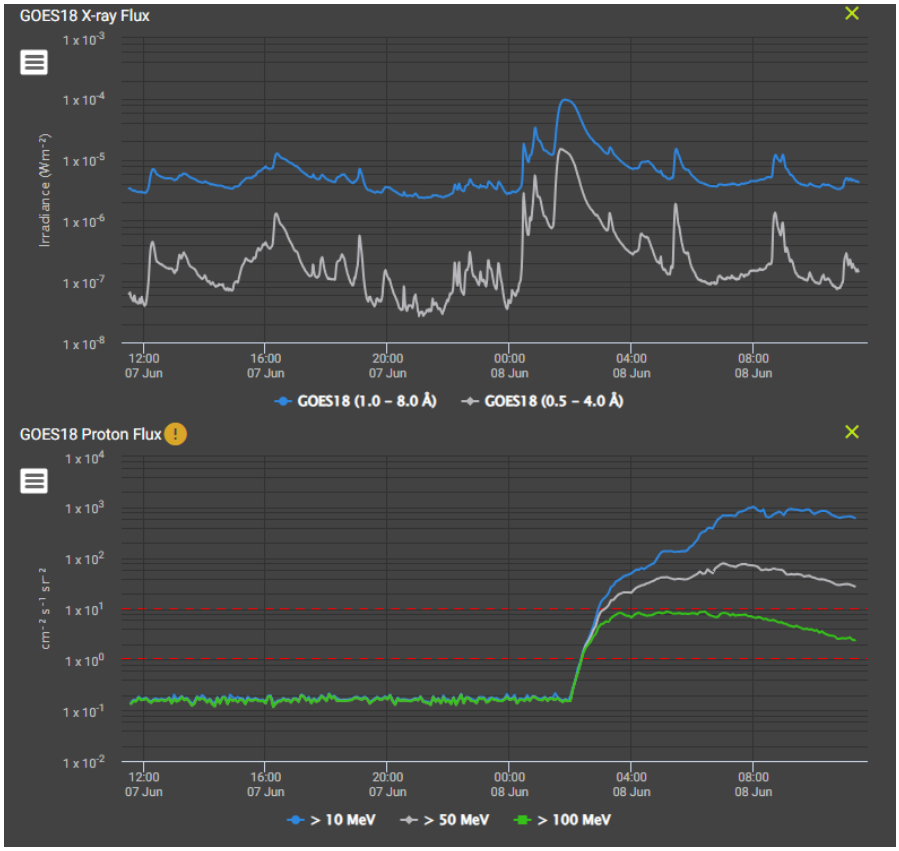
**Figure 3: Past 24 hours GOES18 X-ray flux and proton response – note the hard and relatively immediate response to the M9.7 flare.**




## High Energy Electrons Event (≥ 2MeV):

The high energy electron flux is expected to persist at Normal Background levels for much of this period - now rendered more likely by the inbound CME. CH42/+ could become geoeffective during days 1 and 2 (08 and 09 June), but now in all likelihood forms a minor component of the forecast, with any eventual reaction upwards now delayed until the final UTC day of the period, and even here only rated at a Slight Chance.

MOSWOC REFM output is viewed as generally good guidance in the near term, although it cannot account for the incoming CME and its range is not sufficient to hint at any rise in the T+72-96 hour period.

| **GEO Electron Environment** | **Level ($cm^{-2}$ $sr^{-1}$ $day^{-1}$)** | **Past 24 Hours (Yes/No)** | **Day 1 (00-24 UTC)** | **Day 2 (00-24 UTC)** | **Day 3 (00-24 UTC)** | **Day 4 (00-24 UTC)** |
|---|---|---|---|---|---|---|
| **Probability (Exceedance)** | | | **(%)** | **(%)** | **(%)** | **(%)** |
| **Active** | **≥ 2 MeV ≥ $1x10^8$** | No | 1 | 1 | 1 | 10 |
| **Very Active** | **≥ 2 MeV ≥ $1x10^9$** | No | 1 | 1 | 1 | 1 |

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